DynAmp

LKAT Plus

BI-DIRECTIONAL HIGH CURRENT MEASUREMENT SYSTEM

Installation, Operation and Service Manual

Manual Item No. 043636

Rev. Q

CE

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The LKAT Plus Bi-Directional High Current Measurement System may be used with or without the optional Protection Extensions ("PE") and / or RMS Display PC board assemblies. All configurations of the LKAT Plus System conform to the latest European directives and standards concerning safety and electromagnetic compatibility.

Application of Council Directive(s):

73/23/EEC, 89/336/EEC and 93/68/EEC.

Standards to which conformity is declared:

Electrical Equipment for measurement, control, and laboratory use - EMC Requirements, EN61326:1997 edition, including Amendment 1:1998 and Amendment 2:2001

- **EN55022:1998 edition** - Information technology equipment – radio disturbance characteristics – Limits and methods of measurements
- **EN61000-3-2:2000 edition** - Electromagnetic Compatibility-Part 3:Testing and measurement techniques – Section 2: Harmonic current emissions
- **EN61000-3-3:1995 edition** - Electromagnetic Compatibility-Part 3:Testing and measurement techniques – Section 3: Voltage fluctuation and flicker test
- **EN61000-4-2:1995 edition** - Electromagnetic Compatibility-Part 4:Testing and measurement techniques – Section 2: Electrostatic discharge immunity test
- **EN61000-4-3:1996 edition** - Electromagnetic Compatibility-Part 4:Testing and measurement techniques – Section 3: Radiated, radio-frequency, electromagnetic field immunity test
- **EN61000-4-4:1995 edition** - Electromagnetic Compatibility-Part 4:Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test
- **EN61000-4-5:1995 edition** - Electromagnetic Compatibility-Part 4:Testing and measurement techniques – Section 5: Surge immunity test
- **EN61000-4-6:1995 edition** - Electromagnetic Compatibility-Part 4:Testing and measurement techniques – Section 6: Conducted immunity test
- **EN61000-4-11:1995 edition** - Electromagnetic Compatibility-Part 4:Testing and measurement techniques – Section 11: Voltage dips and interruptions immunity test immunity test

Safety Standards:

- **EN61010-1:2001 edition** - Safety of Electrical Equipment; Part I

CE

Note

According to EN 61326, the manufacturer must state the degradation of performance level acceptable during immunity tests. Unless other wise noted in the manual or data sheet, DynAmp, LLC limits degradation during immunity tests for this equipment to < 1% FS for A-criterion tests.

Under a small number of test conditions, the visual reading of optional RMS Display PC board assembly may deviate up to –35% FS. The display reading returns to specified performance when the RF disturbance is removed. This performance level is acceptable according EN 61326 B-criterion.

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Hazard Warning!

GENERAL

All installation, maintenance and service must be performed by qualified technicians who are familiar with the warnings and instructions of this manual.

Disconnect power to the system before servicing or replacing fuses.

Use of the equipment in a manner not specified by the manufacturer can impair the protection provided within.

The enclosure cover must remain closed at all times during operation to ensure safety of personnel. The cover may be opened using a screwdriver; however, only authorized personnel or technicians should be allowed to open and service the unit.

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HAZARDOUS VOLTAGE

This equipment is designed to be connected to hazardous electric voltages. Ignoring the installation precautions and warnings can result in severe personal injury or equipment damage.

To avoid the risk of electrical shock or fire, the safety instructions and guidelines in this manual must be followed. The electrical specifications must not be exceeded and the unit must be installed according to directions provided.

INSTALLATION

This equipment is intended for indoor or outdoor use. The ambient temperature must not exceed 80°C for the measuring head and 50°C for the electronics.

For mounting considerations that fall outside the recommended specifications provided in this manual, the factory should be contacted for approval.

This unit is rated for installation category III and pollution degree 2.

Symbol Identification:

General definitions of safety symbols used on equipment and manual.

Caution/Warning: Refer to accompanying documents for instructions.

The CE mark proves the compliance of the equipment with the requirements of the directives.

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1. SAFETY

1.1 OVERVIEW

The measuring head is designed to be installed on high voltage bus bars. All interconnection cables must be safely routed away from bus bars and high voltages. Do not allow any interconnection cable to contact bus bars or high voltages.

Ignoring the installation precautions and warnings can result in severe personal injury or equipment damage. The following are general guidelines to be followed during installation, operation and service of the metering unit and measuring head.

- All installation, maintenance and service must be performed by qualified technicians who are familiar with the warnings and instructions of this manual.
- Always follow all local and plant safety procedures.
- The enclosure cover must remain closed at all times during operation to ensure safety of personnel. Only authorized personnel or technicians should be allowed to open and service the unit.
- Replace fuse with correct type, size and value. Refer to the servicing instructions or spare parts list for more information on replacement fuses. Do not bypass the fuses or modify the electronics. Disconnect power to the system before replacing fuses. Failure to follow these instructions will result in intermittent operation and premature failure and will void the warranty.
- Service must be performed by qualified technicians only. If use of an oscilloscope becomes necessary during servicing, either the scope must be floating and ungrounded, or differential probe(s) must be used. The metering unit is isolated from the mains via the power transformers. If a grounded scope is used, a hazardous condition is created since current will flow through the probe to ground.
- Units are not intrinsically safe. Do not place in explosive atmospheres.
- Use of the equipment in a manner not specified by the manufacturer can impair the protection provided within.
- The mains wiring should be sized 18AWG (1mm^2) or larger and have an insulation rating of 1000Vac and 80-105° C temperature rating.
- If a binding screw is used for the mains earth connection, the binding screw must be size M4 (No. 6) or larger.

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2. HANDLING AND STORAGE

DynAmp products are engineered and manufactured for use in industrial environments. However, they contain sensitive electronic and mechanical components which may be damaged and fail if not handled and stored properly. All products must be handled and stored with the same care as any precision measurement instrument. Severe bumps or jolts may damage internal parts and cause malfunction or premature failure. DynAmp products are designed and assembled with conformal coating, shock mounting, and environmental seals, when appropriate or when specified. However, this protection requires that the product must be properly installed and operational before the protection is fully functional. Therefore, adequate protection from humidity, shock, and temperature must be provided during handling and storage prior to installation.

The handling and storage of equipment must be sufficient to meet the storage temperature and humidity specifications of the product and to prevent any condensation or contact with water or any other liquid. The storage location and container or crate must provide adequate protection from precipitation (rain, snow, ice) and direct water contact. Adequate shelter must be provided to prevent the accumulation of precipitation (rain, snow, ice) and water which can lead to the deterioration or failure of shipping containers or crates and cause water ingress. Storage in coastal or industrial areas subject to salt-laden or corrosive air or areas of wind-driven sand or other abrasive dust must be adequate to prevent the deterioration or failure of shipping containers or crates and cause ingress. Frequent inspection of storage areas and storage containers or crates is required to ensure proper storage conditions are being maintained.

If the shipping container or crate is opened and/or the equipment is removed for inspection prior to installation, the equipment must be repackaged in the original undamaged container or crate in the same manner as it was shipped to prevent environmental damage or placed in a storage location that meets the required environmental and storage conditions.

General product storage temperature and humidity requirements:

Storage Temperature:	-40 to 70°C
	-40 to 158°F
Storage Humidity:	85%, non-condensing

DynAmp, LLC does not assume liability for the customer’s failure to comply with handling and storage requirements.

For further assistance, contact DynAmp customer support.

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3. DESCRIPTION

3.1 OVERVIEW

The DynAmp LKAT Plus system is designed to accurately measure AC or DC current flowing in a bus bar. Each system consists of a measuring head, a metering unit, and multi-conductor cables.

3.2 MEASURING HEAD

LKAT measuring heads contain an arrangement of Hall Effect sensor ICs and signal conditioning electronics. The tubular enclosure is constructed of flame retardant plastic materials. Insulation from the bus is provided by the homogeneous (sealed) construction of the head. In the event that the head enclosure components become cracked, the bonding fails, or the weather-tight seal is broken in any way; a replacement head must be substituted. The measuring head is not designed to be repaired.

LKAT measuring heads are mounted on the bus bar using fiberglass channels and spring-loaded clamps. All mounting hardware is supplied with each system. The mounting clamps are factory installed on the measuring head. The spring-loaded plungers are adjusted to bus dimensions specified with each order. When properly installed, the mounting hardware maintains the position of the head in the event of temperature fluctuation and / or bus vibration.

An interconnection cable assembly is integral to each half of the measuring head. The standard length is 33 feet (10 meters). Heads with extra-long interconnection cables are also available - consult the factory for details. Standard head cable assemblies are terminated with keyed connectors to ensure correct hookup. The interconnection cables from the head are identified as “A” and “B”. Connecting head cable “A” to metering unit “B” will not result in damage to the head or electronics, but may degrade the calibration accuracy of the system.

3.3 METERING UNIT

The metering unit is housed in a NEMA 4X enclosure. The enclosure cover must remain closed during normal operation. The Metering Unit is rated IP65, which stipulates the following characteristics:

- Protection from electrical shock as hazardous voltages are inaccessible
- Limited ingress of dust into the enclosure
- Limited ingress of water into the enclosure via dripping, spray, or jets from any direction.

The outside of the metering unit enclosure includes four receptacles for external connection to the measuring head, the metering unit outputs, and the input power. When properly mated with the associated cable assembly, these connectors are also rated IP65. External power for the metering unit is “universal input” type: 85 to 264Vac @ 47 to 440Hz, or 110 to 264Vdc. Wiring changes are **not required** for any supply voltage in this range. Burden on the supply circuit will not exceed 30VA.

All LKAT Plus metering units include power supply and Main pc board assemblies (one each). These are mounted on a steel chassis mounted on a steel panel housed in the enclosure.

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The metering unit enclosure cover is made of clear polycarbonate. This allows the user to view various LED (or LCD) status indicators. For more information, refer to the "Theory of Operation" section of this manual.

There are two optional pc board assemblies that may be added to the LKAT Plus metering unit:

- Protection Extensions ("PE") pc board assembly
- Display pc board assembly (configurable for DC or True RMS readings).

One or both of these pc board assemblies may be added to an LKAT Plus Metering Unit in the field. It is not mandatory that they be factory installed and/or calibrated. The optional pc board assemblies may be calibrated on site, using the LKAT Plus Main Output as the reference measurement.

3.4 INDICATORS AND OUTPUTS

The LKAT Plus System metering unit includes several visual indicators. These include:

- Accuracy Diagnostics (operational status) LEDs: green = OK, red = system problem (see Section - "Theory of Operation").
- Overcurrent / Reverse Current Trip status LEDs: green = measured current less than setpoint, red = overcurrent / reverse trip. The overcurrent trip setpoint(s) may be configured to monitor forward or reverse current.
- (Optional) Illuminated LCD digital display of measured current.

Available via the metering unit output cable:

- Isolated signal output proportional to bus current being measured. This output may be configured specified for various zero and full-scale values.
- Normally open and normally closed relay contacts indicate operational status (same as green and red LEDs). For failsafe operation, the relay coil is energized when unit is functioning properly.
- Normally open and normally closed relay contacts indicate overcurrent trip status (same as green and red LEDs). For failsafe operation, the relay coil is energized when measured current is less than overcurrent trip setpoint(s).

The table below lists the features associated with the Main and PE pc board assemblies:

Table 3.1
Main and PE PC Board Assembly Features

	Main PC Board Assembly	PE PC Board Assembly
Isolated Output	1	1
Operational Status LEDs & Relay Contacts	1	0
Overcurrent / Reverse Trip Status LEDs & Relay Contacts	1	2

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Each isolated output features:

- 450Vrms working galvanic isolation
- Configurable scaling
- Configurable bias

Each Overcurrent / Reverse Current Trip Setpoint includes:

- Selectable Forward / Reverse protection
- Independently adjustable Trip Setpoint (field configurable)
- Status LEDs
- Status Relay Contacts

Field calibration of LKAT Plus Systems requires use of a reference current transducer with calibration accuracy of 0.1% full-scale or better. Contact DynAmp, LLC for calibration of the LKAT Plus System. Refer to “Maintenance and Spare Parts” section for more information.

3.5 INTERCONNECTION CABLES

The LKAT Plus system is supplied with two cable assemblies in addition to those connected to the measuring head.

The power input cable assembly is 33 feet (10m) in length. A keyed circular connector terminates one end. The other end is unterminated for connection to the power source by the user during installation.

The system output cable assembly is 100 feet (30m) in length. A keyed circular connector terminates one end. The cable is a 10-conductor type; however, only 5 of the 10 conductors are used. The unused conductors may be trimmed flush to cable jacket. The user connects this cable from the metering unit to the appropriate inputs during installation.

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4. SPECIFICATIONS

Table 4.1
LKAT Plus System Specifications

ANALOG SIGNAL OUTPUT – MAIN & PROTECTION EXTENSIONS	
Full-Scale Measuring Range (Main Output)	±5kA to ±100kA
Contact factory for Full-scale measuring range >100kA	
Full-Scale Protection Range (PE Output)	±5kA to ±200kA
Signal Output Calibration Accuracy	±0.75% full-scale
Signal Output Type (configurable)	±20mA, ±1 Volt, or ±10V Full-Scale
Signal Output Maximum Burden	10 volts
Maximum Load Resistance (Current Loop Output)	500Ω
Minimum Load Resistance (Voltage Output)	100kΩ
Linearity Error	±0.1% of full-scale
Repeatability Error Limits	±0.1% of full-scale
Temperature Sensitivity (Note 1.)	±0.02%/°C
Response Time (t_d)	≤ 50 μs
di/dt Accurately Followed	500 A/μs
Frequency Response	(refer to Figure 4.1)
Line Voltage Sensitivity	±0.001%/V
STATUS INDICATORS – MAIN PC BOARD ASSEMBLY	
Accuracy Diagnostics Status Relay (Normally Open & Normally Closed Contacts)	Indicates proper operation or operational problem
Accuracy Diagnostics Status LEDs	Green LED indicates proper operation Red LED indicates operational problem
Overcurrent / Reverse Current Trip Setpoint -Qty. (1) - Field configurable	Continuously variable from 5% to 100% of full-scale.
Overcurrent / Reverse Current Status Relay (Form C contacts Normally Open & Normally Closed)	Relay coil de-energizes when measured current exceeds Trip Setpoint
Relay Contact Rating	7 Amps – 120/250 Vac 7 Amps – 30 Vdc
Overcurrent / Reverse Current Status LEDs	Green LED indicates operation OK – No Trip Red LED indicates measured current exceeds Trip Setpoint

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Table 4.1
LKAT Plus System Specifications, Continued

STATUS INDICATORS PROTECTION EXTENSIONS PC BOARD ASSEMBLY (Optional)	
Overcurrent / Reverse Current Trip Setpoint - Qty. (2) - Field configurable	Independent, Continuously variable from 5% to 100% of full-scale.
Overcurrent / Reverse Current Status Relay (Form C contacts Normally Open & Normally Closed)	Relay coil de-energizes when measured current exceeds Trip Setpoint
Relay Contact Rating	7 Amps – 120/250 Vac 7 Amps – 30 Vdc
Overcurrent / Reverse Current Status LEDs	Green LED indicates operation OK – No Trip Red LED indicates Measured Current exceeds Trip Setpoint
STATUS INDICATORS – RMS DISPLAY PC BOARD (Optional)	
Digital Display of Bus Current in kA units	3 ½ Digit Green LCD ±2% Full-scale
Displayed Value (configurable)	DC average or True RMS
METERING UNIT GENERAL SPECIFICATIONS	
Input Power	85 to 264Vac @ 47 to 440Hz, or 110 to 264Vdc.
Burden on ac Line (max)	30 VA
Working Voltage: Signal Output to Metering Unit Low Voltage Circuit	450Vrms
Working Voltage: Bus to Metering Unit Low Voltage Circuit	1500Vdc
Working Voltage: Mains Supply to Metering Unit Low Voltage Circuit	264Vrms
Working Voltage: Mains Supply to chassis	264Vrms
Working Voltage: Output to chassis	450Vrms
Installation Category	III
Pollution Degree	2
ENVIRONMENTAL	
Ambient Temperature Range of Metering Unit Location (Operational)	-10°C to 50°C (14°F to 122°F)
Ambient Temperature Range of Measuring Head (Operational)	-20°C to 80°C (-4°F to 176°F)
Ambient Temperature Range of System (Storage)	-40 to 70°C (-40 to 158°F)
Humidity (head and metering unit)	85%, non condensing

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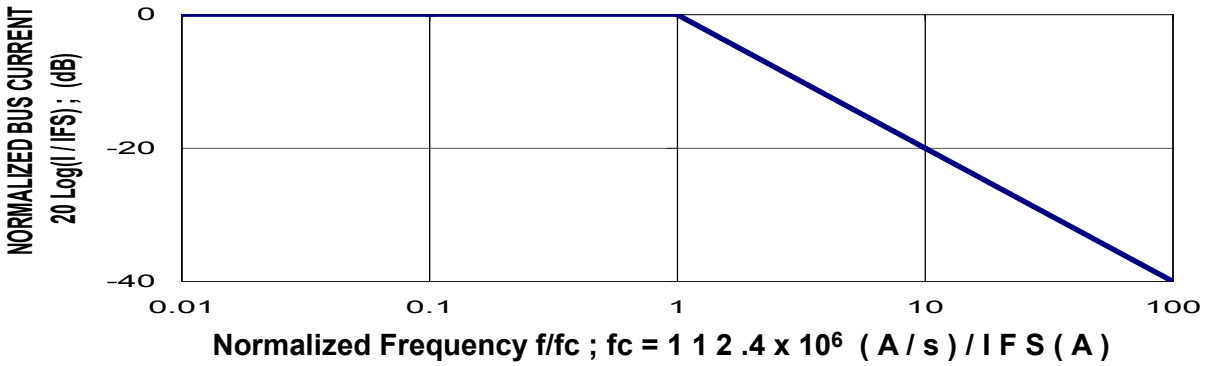
Table 4.1
LKAT Plus System Specifications, Continued

PHYSICAL	
Measuring Head Weight	2 to 8 lbs. (1 to 4 kg)
Metering Unit Weight	8 lbs. (4 kg)
Head Interconnection Cables (2) - Standard Length	33 ft. (10 m)
Head Interconnection Cables (2) - Custom Length (Note 1.)	Up to 164 ft. (50 m)
Signal Output Cable (1)	100 ft. (30 m)
Power Input Cable (1)	33 ft. (10 m)
Environmental rating: Head, Metering Unit, and Interconnection Cables	IP65

Note 1.) For head interconnection cable lengths exceeding 20m the temperature sensitivity increases ±0.02% / ºC per 10m additional cable length.

Normalized LKAT Bandwidth



F.S. Bus Current (kA)	5 to 50	60	70	80	90	100
Corner Frequency (kHz)	2.248	1.873	1.606	1.405	1.249	1.124

Figure 4.1
LKAT Plus Frequency Response

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5. INSTALLATION

5.1 HANDLING PRECAUTIONS

LKAT Plus systems should be handled with the same care as any precision measuring instrument. Severe jolts or bumps to the head or metering unit may cause movement of internal parts, and possibly a malfunction. **Personnel involved in the installation should be familiar with the technical terms, warnings, and instructions in this manual, and all plant safety rules, and be able to follow these.**

The complete system should be inspected for shipping damage at the earliest opportunity. Visible damage must be reported to the carrier immediately. Concealed damage (not evident until the system is operated) must be reported to DynAmp, LLC immediately.

NOTE
It is normal to hear a slight “rattling” sound when the LKAT Measuring Head is subjected to vibration.

5.2 INSTALLATION CONSIDERATIONS

Read the following before mounting the head:

1. The measuring head is designed to be installed on high voltage bus bars. All interconnection cables must be safely routed away from bus bars and high voltages. Do not allow any interconnection cable to contact bus bars or high voltages. Ignoring the installation precautions and warnings can result in severe personal injury or equipment damage.
2. Always follow all local and plant safety procedures when the unit is to be installed on a live bus.
3. Choose a mounting location for the head where the ambient air temperature does not exceed 80°C. The LKAT Plus head may be located indoors or outdoors, but should be kept away from extreme heat and solvents. Head installations in direct sunlight are not recommended, as excessive temperature rise could result in measurement error or damage to the head enclosure. If the head is to be installed in an especially harsh environment, please contact the factory to discuss special requirements.
4. The head and metering unit are rated IP65. No part of the head or Metering Unit should be submerged under water. **RTV sealant must be used** to seal the measuring head halves together during installation. If RTV is not used, the IP65 rating does not apply to the measuring head.
5. For best performance, the head should be mounted in an area free of other bus bars. This is not an essential requirement if a satisfactory magnetic centering can be achieved.
6. The head must be installed with proper polarity. An arrow indicates the direction that conventional bus current must flow through the aperture (+) to (-). No damage will occur if the head is reversed, but the system output will indicate current flow in the reverse direction.
7. Measuring heads are shipped in matched halves. Make sure that the same serial number is present on the both halves of the measuring head and the metering unit. The two head halves should mate squarely and evenly without forcing or twisting.

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8. The measurement head is not grounded; however, the head cables should be disconnected from the metering unit prior to installation or maintenance to minimize the possibility of electrical shock. When properly connected, the power input cable will ground the LKAT Plus Metering Unit panel. Refer to drawings at the end of this manual and connection detail on the side of the LKAT Plus Metering Unit enclosure.
9. When installing the sensor head, do not remove the seals from the exposed end of the sensor head tube. Doing so may allow water or contaminants to enter the head, and void IP rating and warranty.
10. Measuring heads are shipped with mounting hardware installed and adjusted to the bus size specified with each order. For permanent installation, the head halves must be semi-permanently bonded around the bus bar using Silicone RTV sealant (adhesive). After the bond cures, the spring-loaded mounting screws (plungers) may require adjustment for appropriate position and spring force on the bus.

Whenever possible, the head should be installed on the longest straight run of the bus that is available in an area free of other bus structures. The status LEDs and relay contacts indicate proper operation in a given head location.

5.3 OFF-BUS FUNCTIONAL CHECK (OPTIONAL)

After unpacking the LKAT Plus system (but prior to installation) the following functional check of the system is recommended:

1. Locate a convenient temporary power source for the LKAT Plus system. This may or may not be in the location where the system will be installed. The power source must be in the range 85 to 264Vac @ 47 to 440Hz, or 110 to 264Vdc. The system draws a maximum of 30 volt-amperes.
2. Refer to the drawing “Wiring Diagram, LKAT Plus System” included at the end of this manual. Attach a suitable connector to the unterminated end of the input power cable assembly for connection to the power source to be used for this check.
3. Connect the measuring head cables A & B to the metering unit.
4. Connect the power input cable assembly to the metering unit and energize the unit.
5. Observe the LEDs on the Main pc board assembly. If the LEDs light green, the system is functioning properly. If LED D6 (Accuracy Diagnostics “AD”) lights red, skip to “Troubleshooting an Accuracy Diagnostics Fault Indication” in the “Theory of Operation” section of this manual. If LED D5 (Trip 1) lights red, make measurements and complete the form “LKAT Plus Diagnostic Measurements Form 1 – Zero Primary Current” and contact the factory.

Refer to “LKAT Plus Diagnostic Measurements Form – Zero Primary Current”. Allow the system one hour to stabilize prior to making measurements. Make measurements and record data shown on the form. File the completed test form for future reference. It is OK to make these measurements away from location where the LKAT Plus system will be installed, but this should be noted on the form

5.4 HEAD INSTALLATION

The head halves are semi-permanently bonded together around the bus. The measuring head is comprised of two “L” shaped halves. Each half is identified with a serial number followed by an “A” or “B”. One interconnection cable exits from each corner box on each half.

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When the sensor head is installed on a running (“horizontal”) bus, the corner boxes should be located beneath the bus. This reduces chances of ingress by pollutants and minimizes heating of the head electronics by the bus.

For rising (“vertical”) busses, the corner boxes may be located on either side of the bus, depending on mechanical and thermal considerations. The head should be mounted so conventional (+) to (-) current flows in the direction of the arrow on the sensor head.

The following tools and materials are required for installation:

Materials marked with an asterisk (*) are included with each LKAT Plus System order.

34” (864mm) Releasable Cable Ties *
Silicone RTV adhesive / sealant *
1/8” (3mm) hex wrench *
Drill, drill bits, mounting hardware, screwdrivers, wrenches, etc.
Cable puller, cable ties, ladder, etc.

•

The following is the recommended sequence for installing the measuring head:

1. Determine the position where the measuring head will be installed. Bus bar(s) should be free from grease and dust for the best adhesion of the LKAT fiberglass mounting channels to bus bar(s).
2. Connect the head cable assemblies to the metering unit.
3. Remove the backing from the adhesive foam strips on the fiberglass mounting channels. Position the mounting channels to the bus in the desired location.
4. Squeeze a ¼” (6.5mm) continuous bead of silicone RTV adhesive around the elbow and tube seam indicated by the yellow “HEAD SPLITS HERE” marker. Keep the Silicone RTV on the outside of the elbow cavity. There must be sufficient Silicone RTV adhesive to seal any gap between the sensor head halves.
5. Position the two “L-shaped” head halves around the bus and the fiberglass channels. Mate the two halves, pressing them together until the tubes are firmly seated in the elbows.
6. Install the releasable cable ties to hold the head halves together while the Silicone RTV cures. The cable ties may be removed after 24 hours.
7. Route the interconnection cables away from the bus and other high voltages.
8. Connect the power cable assembly to appropriate power source and LKAT Plus metering unit.
9. The Silicone RTV takes approximately 24 hours to cure. After Silicone RTV has cured, the plunger tension may be adjusted, if needed. Use the 1/8” hex wrench supplied with the system for this purpose.

5.5 SYSTEM CHECKOUT

Recheck all wiring connections against the drawings to ensure proper installation. Energize the LKAT Plus system. Confirm that the green status LEDs are illuminated. If D6 (AD LED) lights red, skip to “Troubleshooting an Accuracy Diagnostics Fault Indication” in the “Theory of Operation” section of this manual

With the bus energized, the metering unit digital display should indicate the primary current (in kA units) within ±2%. The current loop should produce an output signal of +20mA (±0.75%) at full-scale bus current, with allowance for any bias offset.

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Photocopy the appropriate LKAT Plus Diagnostic Measurements Forms. Form 1 is for diagnostic measurements at zero bus current (with the sensor head on or off the bus). Form 2 is for diagnostic measurements with the sensor head installed on the bus with the bus energized. Follow the directions to measure and record necessary information.

NOTE :

- These forms are intended to help keep accurate records of LKAT Plus functional tests.
- This information may prove valuable in the event of a malfunction.
- These measurements do not constitute system calibration.
- Space is provided for the recording of three sets of readings.
- Voltages may vary slightly with temperature extremes.
- System performance will typically remain within nominal specifications when measured levels fall within the acceptable limits shown on the forms.
- Levels must be measured and recorded under test conditions shown on the forms.
- The metering unit cover must be open during system checkout, as all measurements are made inside metering unit on Main pc board terminal blocks. The cover should remain firmly closed during normal operation.
- **Always** complete these forms **before** contacting the factory.

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Table 5.1
LKAT Plus Diagnostic Measurements Form 1 – Zero Primary Current

LKAT Plus Diagnostic Measurements Form
Zero Primary Current

Instructions:
1.) Assure that the metering unit is energized and both head halves are connected.
2.) Assure that head is off bus, or that bus is de-energized.
3.) Measure and record the information below (make additional copies of this form as needed).

TEST CONDITIONS:

ZERO PRIMARY CURRENT (Head may or may not be installed on bus);

LKAT Plus SYSTEM must be ENERGIZED for AT LEAST ONE HOUR.

MEASURE	(+) DMM at	(-) DMM at	ACCEPTABLE RANGE	DATE ____/____/___	DATE ____/____/____	DATE ____/____/___
+5V supply	P4-1	P4-2	+5V (±0.5V)			
+15V supply	P4-3	P4-4	+15V (±0.5V)			
-15V supply	P4-6	P4-5	-15V (±0.5V)			
Input A1	P1-1	P1-2	0V (±5mV)			
Input A2	P1-3	P1-2	0V (±5mV)			
Input B1	P2-1	P2-2	0V (±5mV)			
Input B2	P2-3	P2-2	0V (±5mV)			
Output Current Loop Burden at Full-Scale	P3-1	P3-2	10.2V max			

Serial Number _____

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Table 5.2
LKAT Plus Diagnostic Measurements Form 2 – Energized Primary Bus

LKAT Plus Diagnostic Measurements Form
Energized Primary Bus

Instructions:
1.) Assure that the metering unit is energized and both head halves are connected.
2.) Assure that head is on bus and that bus is energized.
3.) Measure and record the information below (make additional copies of this form as needed).
4.) Record Serial Number and Current Loop Burden Resistance (Ohms)

TEST CONDITIONS:

ENERGIZED PRIMARY BUS ;

LKAT Plus SYSTEM must be ENERGIZED for AT LEAST ONE HOUR.

MEASURE	(+) DMM at	(-) DMM at	ACCEPTABLE RANGE	DATE ___/___/___	DATE ___/___/___	DATE ___/___/___
+5V supply	P4-1	P4-2	+5V (±0.5V)			
+15V supply	P4-3	P4-4	+15V (±0.5V)			
-15V supply	P4-6	P4-5	-15V (±0.5V)			
Input A1	P1-1	P1-2	Within ±25mV of Input A2			
Input A2	P1-3	P1-2	Within ±25mV of Input A1			
Input B1	P2-1	P2-2	Within ±25mV of Input B2			
Input B2	P2-3	P2-2	Within ±25mV of Input B1			
Output Current Loop Burden at Full-Scale	P3-1	P3-2	10.2V max			

- Serial Number _____ Nominal Current Loop Burden Resistance (Ohms) _____

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5.6 METERING UNIT INSTALLATION

The location of the metering unit should be determined by the following factors:

1. Ambient air temperature must stay in the range of -10°C to +50°C at all times.
2. The location should not be exposed to direct sunlight.
3. The location should be within reach of the head cables supplied with the system. Standard head cable length is 33 feet (10 meters). Extra long head cables may also be ordered for special applications.
4. Route interconnection cables away from bus and other high voltages.

Refer to Metering Unit Outline & Mounting drawing at the end of this manual. Anchor the cabinet in the desired location after ensuring adequate cable reach.

Refer to the LKAT Plus System Wiring Diagram. The output cable assembly consists of 20AWG twisted pair cable (8 pairs) with 17 (one contact position in output connector is unused) position circular connector on one end, and stripped, tinned wires on the other end. The twisted wire pairs are jacketed with black and white PVC. Each pair has the pair number imprinted on the jacket. Connect the output cable assembly wires to the appropriate points in the process electronics system.

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6. THEORY OF OPERATION

6.1 GENERAL

The LKAT Plus system uses open-loop, open-path (OLOP) technology to convert the magnetic field associated with a current carrying conductor into an isolated milliampere current loop output. This output is scaled to be proportional to the primary conductor current. In addition, a local digital display of the primary bus current (in kiloAmperes) is visible when the optional RMS Display pc board is added to metering unit.

The measurement head is a sealed unit and is not designed for repair in the field. However, a working knowledge of the LKAT Plus system theory of operation will help facilitate timely and accurate diagnosis in the event of problems.

6.2 OLOP TECHNOLOGY

The term “open-loop” means that the magnetic circuit does not generate an opposing magnetic field to null the field produced by the primary conductor. The term “open-path” indicates that the sensor is an air-core design, without magnetic core material.

The LKAT Plus system operation is based on Ampere’s Law, which states: “the line integral of B (magnetic flux density) around any closed path is equal to $\mu_O I$ (permeability times current)”. In practical terms, this means that integrating a closed path around a primary conductor will yield the net primary current.

This integration is implemented using a specific array of Hall Effect ICs. The LKAT Plus system effectively minimizes errors typically present in other open-loop sensors: zero drift, thermal drift, position sensitivity, and susceptibility to external magnetic fields. The absence of a magnetic core practically eliminates errors due to saturation, hysteresis, and core set (remanance) commonly associated with ferrite material.

A generalized block diagram of the LKAT Plus system is shown in Figure 6.1.

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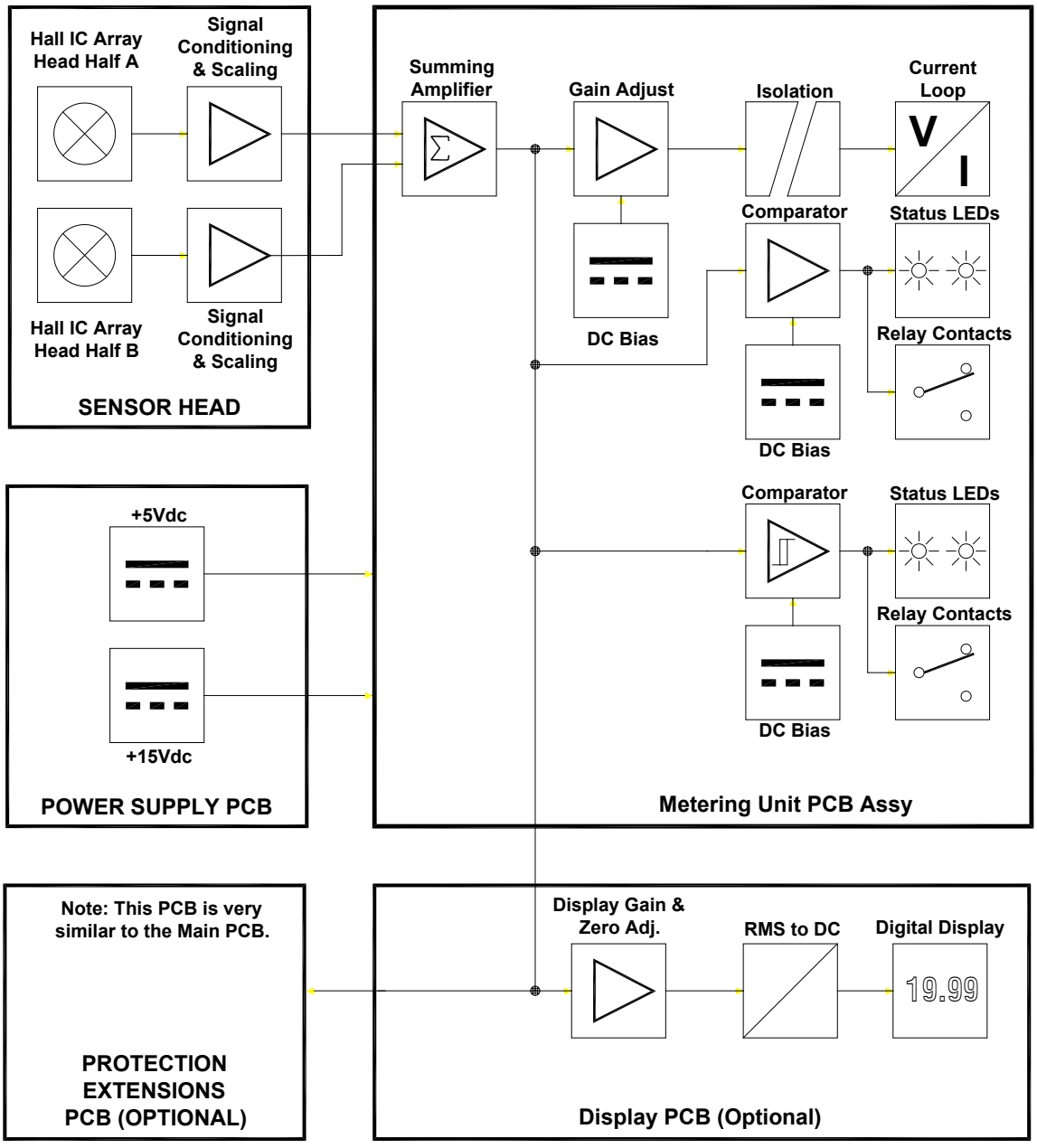

Figure 6.1
Block Diagram of the LKAT Plus System

6.3 SYSTEM FUNCTIONAL DESCRIPTION

The flux density associated with the primary current is sensed by arrays of Hall ICs in the sensor head. The outputs of these devices are summed and filtered, then transmitted to the metering unit where these signals are dc biased and scaled. The Accuracy Diagnostics status LEDs and relay contacts are driven by a signal input that compares the various Hall groups with voltage setpoints. When the Hall group signal exceeds the reference, the green

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LED will go out and the red LED will illuminate. The relay coil will de-energize under the same conditions. The Trip Setpoint LEDs and relay contacts operate in a similar manner.

Main PCB LED D6 is a RED / GREEN the Accuracy Diagnostics status LED. This LED indicator and Main PCB relay CR2 contacts may be used to monitor the following conditions:

- Head imbalance
- Power supply failure
- Head disconnected
- Sensor electronics failure
- Other circuit failures causing loss of measurement accuracy

Occurrence of one or more of the conditions above will deenergize CR2 relay coil, changing the state of the contacts and changing the LED indication from green to red. Refer to the section “Troubleshooting an Accuracy Diagnostics Fault Indication” in this section for more information about determining the cause and eliminating a fault condition.

6.4 LKAT PLUS METERING UNIT

Refer to drawings in the back of this manual. The LKAT Plus metering unit consists of a universal input power supply and Main pc board mounted together on a steel U-chassis. Input, output, and power connections are made from outside the enclosure using panel-mount IP65 rated military-style circular connectors. Wiring harnesses within the metering unit are terminated using 3.5mm and 5.08mm “Eurostyle” connectors.

Input power connects to the Power Supply pc board assembly. The dc supply includes a slo-blo type fuse, in-rush and overcurrent protection, as well as MOV overvoltage clamping. The power supply provides outputs of ±15Vdc and +5Vdc required by the system electronics. These outputs connect to the Main pc board assembly via a short wire harness.

Connections to the sensor head are made via the Main pc board assembly. The u-chassis with power supply and Main pc board is mounted on a sub-panel inside NEMA-4X enclosure. The enclosure cover must be securely closed and cable assemblies connected at all times during normal operation.

6.5 HEAD INTERCHANGEABILITY

Measuring heads of various sizes will operate properly when connected to the LKAT Plus metering unit. However, the LKAT Plus system is ***factory calibrated as a system*****.** As a result, optimal measurement accuracy is achieved when the metering unit is connected to the head it was calibrated with, and installed on the size bus bar it was designed for.

6.6 TROUBLESHOOTING AN ACCURACY DIAGNOSTICS FAULT INDICATION

A problem may exist when the LKAT Plus system is energized with A and B head cables connected to the metering unit and the Main PCB AD status LED D6 illuminates RED and / or Main PCB CR2 status relay coil de-energizes. This is true whether or not the measuring head is installed on the bus. The following table is intended to help the user determine and hopefully eliminate the cause of the fault.

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Table 6.1
Troubleshooting an Accuracy Diagnostics Fault Indication

Main D6 Green LED	Main D6 Red LED	Contact P3-3 to P3-5	BUS ON	BUS OFF	Possible problem	Action / Check
ON	OFF	Open	X	X	System operating	• DC measurements (optional)
OFF	OFF	Closed	X	X	No input power	Verify input power connection
OFF	OFF	Closed	X	X	DC power supply	Verify DC power on main pcb
OFF	ON	Closed	X	X	Head halves disconnected	Verify head interconnections at metering unit
OFF	ON	Closed	X		Head imbalance	Adjust position of head for green ON, red OFF
OFF	ON	Closed	X	X	Sensor head malfunction	Measure head input signals at zero bus current; output should be < 5mVdc; substitute known good sensor head
OFF	ON	Closed	X	X	Other problem	Contact factory

6.7 SYSTEM CALIBRATION OVERVIEW

DynAmp does not specify required intervals of calibration for its products.

The end user of the product is responsible for identifying the appropriate interval between calibrations. The intervals should be determined based on the following factors:

- Requirements of a Quality Management System
- Accuracy and permissible limits of errors
- Purpose and usage
- Experience with similar products
- Manufacturer's recommendations
- Stability of the product
- Past history
- Other characteristics of the product

Reference: "ISO/IEC 17025:2005, General requirements for the competence of testing and calibration laboratories" and Laboratory Accreditation Bureau "Guidance for Documenting and Implementing ISO/IEC 17025:2005 and Laboratory Guidance."

As a guideline, DynAmp recommends a 24-month interval of calibration for all permanently installed products and a 12-month interval of calibration for all products used in portable applications.

The DynAmp, LLC LKAT Plus Current Measurement System is factory calibrated for accuracy of 0.75% of full-scale measured current (or better).

Calibration may be performed as:

- Field Calibration (On Process Bus)
- Field Calibration (On Test Bus)
- Factory Calibration

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IMPORTANT NOTE
DynAmp, LLC assumes no responsibility for the accuracy of LKAT Plus Systems calibrated by any person other than a DynAmp, LLC Technician.

To calibrate the LKAT Plus System, one compares the output of the device under test ("DUT") to a reference. During field calibration, a 0.1% accurate current measurement system, such as the DynAmp LKP or LKB, may be used as a reference. Due to significantly larger size and mass, it may be difficult to install a comparably rated LKP or LKB measuring head in on the same bus as the LKAT Plus sensor head to be calibrated.

When several LKAT Plus sensors of the same size and scaling are used in a rectifier or at one location, the use of a DynAmp, LLC factory-calibrated LKAT Plus System may be used as a reference. Approval of this approach typically depends on the accuracy requirements of the measurement application.

LKAT Plus calibration may be performed on a test bus current that is less than the full-scale current of the LKAT Plus System. It is advisable to use a test bus current of 50% (or more) of LKAT Plus System rating. The calibration accuracy depends on the stability of the test bus current, the accuracy of the reference current measurement system and ammeters, as well as the linearity of the LKAT Plus System.

LKAT Plus Systems may be returned to the factory for calibration on a test bus at full-scale current. This requires that the LKAT Measuring Head be removed from process bus. The head and associated metering unit must be returned together, and should have the same serial number. The signal output and input power cable assemblies need not be returned during factory calibration. Specific details of factory calibration are beyond the scope of this manual.

6.8 CALIBRATION PROCEDURE

IMPORTANT NOTE
To avoid injury and/or electrical shock, personnel performing calibration must review and observe all hazard warnings and safety precautions stated throughout this product manual.

Calibration of the LKAT Plus System is summarized below. All Bias and Zero adjustments are made at zero bus current. All Scaling and Gain adjustments are typically made at Full-scale current. Refer to pc board assembly drawings at the end of this manual for location of switches and potentiometers, as well as tables listing proper switch settings. Except for step 1) below, each table is shown on the appropriate pc board assembly drawing.

Use forms shown in Tables 5.1 and 5.2 to check and record system power supply and channel voltages.

NOTE
The Optional PE and/or RMS Display pc board assemblies may be installed and calibrated in the field. Use the Main pc board assembly output signal for the Reference output signal with the LKAT Plus System measuring normal bus current.

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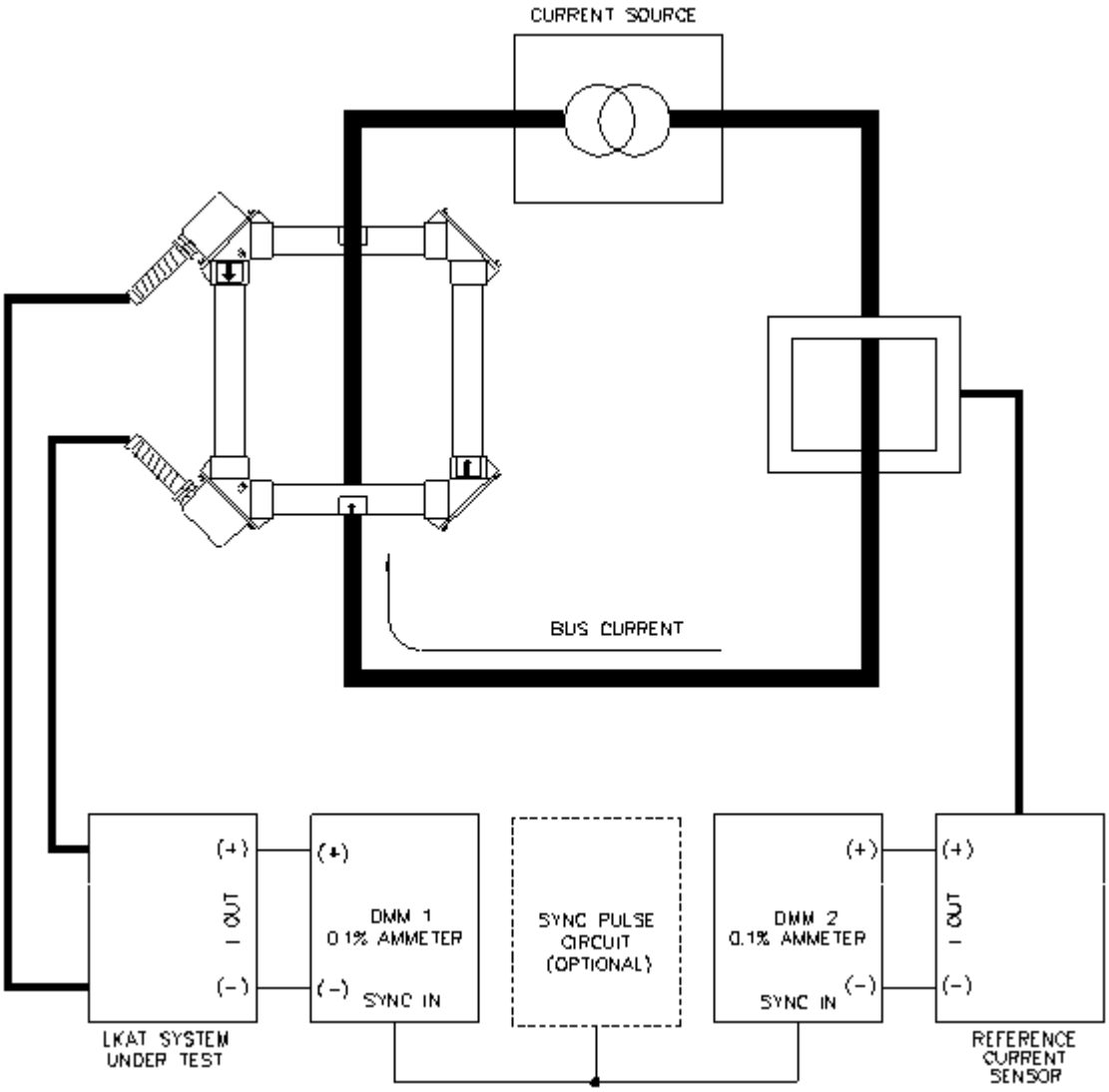

Figure 6.2
LKAT Plus System Test Setup

Calibrate the Main PCB Current Loop Output

- Set Output Bias (coarse) using SW4
- Set Output Type using SW5
- Remove tape seal from switch SW1 and SW2, if necessary. Adjust Output Gain (coarse) using SW1 and SW2
- Adjust Output Bias (fine) using R42
- Adjust Output Gain (fine) gain using R7
- Readjust Output Bias (fine) using R42 (if required)

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Calibrate the PE PCB Current Loop Output (Optional)

- Set Output Bias (coarse) using SW4
- Set Output Type using SW5
- Remove tape seal from switch SW1 and SW2, if necessary. Adjust Output Gain (coarse) using SW1 and SW2
- Adjust Output Bias (fine) using R42
- Adjust Output Gain (fine) gain using R7
- Readjust Output Bias (fine) using R42 (if required)

Calibrate the Main PCB – Trip 1 Setpoint

- Select Trip 1 Protection Polarity using SW3
- Adjust Trip 1 Setpoint using R33 (coarse) and R46 (fine)

Calibrate the PE PCB Trip 2 & 3 Setpoints

- Select Trip 2 Protection Polarity using SW3
- Adjust Trip 2 Setpoint using R33 (coarse) and R46 (fine)
- Select Trip 3 Protection Polarity using SW3
- Adjust Trip 3 Setpoint using R34 (coarse) and R47 (fine)

Calibrate the RMS Display PCB Assembly

- Select Decimal Point position
- Select DPM Mode
- Select RMS Signal Conditioning Options using SW1F, G, & H (SW1-6, 7, & 8)
- Select Input Scale Factor using SW1E (SW1-5)
- Select Input Attenuation using SW1A, B, C, & D (SW1-1, 2, 3, & 4)
- Set DPM Gain (fine) using R12

6.9 FIELD CONFIGURATION OF TRIP SETPOINTS

Trip setpoints may be re-configured on site for any level between 5% and 100% of full-scale. The trip polarity may also be re-configured on site. However, the Accuracy Diagnostics trip setpoint should not be adjusted without consulting the factory.

Refer to assembly drawings for the Main pc board and PE pc board (optional) included at the end of this manual. To change trip polarity adjust SW3-1 and SW3-2 according to the table on the assembly drawing.

The trip setpoint is proportional to the current where the trip will occur: “Trip Current” – from LKAT Plus Metering Unit nameplate. To configure the trip setpoint:

Refer to Table 6.2, “Trip Configuration Details”. Adjust coarse and fine potentiometers to produce calculated New $V_{STPT.}$

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Measure the existing setpoint voltage (V_{STPT}); use the equation below to calculate the new setpoint voltage.

$$\text{New } V_{STPT} = \frac{\text{Old } V_{STPT}}{\text{Old Trip Current}} \times \text{New Trip Current}$$

Example: Old V_{STPT} = 7V
Old Trip Current = 70kA
New Trip Current = 80kA

$$\frac{7V}{70kA} \times 80kA = 8V \text{ (New } V_{STPT})$$

Table 6.2
Trip Configuration Details

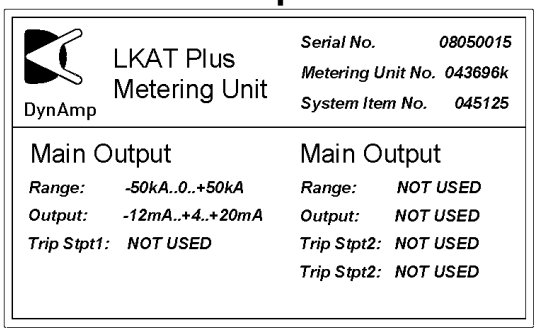
Trip Circuit	V_{STPT} Location	Coarse Adjust	Fine Adjust
1 (Main)	TP2 (Main	Set 1	Set 1 Fine
2 (PE)*	TP2 (PE)*	Set 2	Set 2 Fine
3 (PE)*	TP3 (PE)*	Set 3	Set 3 Fine
Use P1-2 for zero volt reference (circuit common) for voltage measurements for trip setpoint configuration.			

* Optional

NOTE

The LKAT Plus is supplied with trip setpoints configured as specified in the LKAT Plus Worksheet. If the trip setpoints are reconfigured in the field, the customer must realize that the trip setpoints shown on the LKAT Plus Metering Unit nameplate will no longer be correct. In this case, DynAmp suggests that the nameplate be changed to reflect the new trip setpoint (following reconfiguration). The nameplate location and suggested method for documenting new trip setpoint(s) are shown in the figure below.

Figure 6.3
Nameplate



6.10 EARTH GROUNDING

Many local electrical codes require non-conducting metal parts of electronic equipment to be connected to Earth Ground for safety reasons. This connection is intended to prevent electrical shock if the Input Mains Line voltage is accidently connected to normally non-conducting metal parts of the equipment. In a failure where the chassis is accidently connected to Mains Line voltage, current will flow via the connection to Earth. This in turn will trip the protective circuitry on the Mains Line.

Here is a detailed description of the Earth Ground connection path (See Figure 6.4):

1. The BLK and WHT wires of the Input Power Cable Assembly are connected by the customer to Mains Power. The GRN wire may or may not be connected to Earth Ground, depending on the local electrical code where the LKAT equipment is installed.
2. CONN4F is the connector end of the Input Power Cable Assembly. CONN4F contacts are connected BLK = Contact “A” (LINE or +VDC), WHT = Contact “C” (NEUTRAL or -VDC) and GRN = Contact “E” (Earth Ground).
3. CONN4F mates with the front side of CONN4M flanged connector on the Metering Unit Enclosure.
4. On the back side of CONN4M, its contacts terminate one end of the Input Power Harness.
5. Plug P5 terminates the other end of the Input Power Harness. P5-4 is the Earth Ground conductor
6. Plug P5 mates with Receptacle P5 on the Power Supply PC Board Assembly.
7. Receptacle P5 is soldered to copper foil traces on the Power Supply PC Board Assembly.
8. The copper trace connected to P5-4 makes electrical contact with the steel standoff inserts of the steel PCB mounting bracket.
9. The PCB mounting bracket makes electrical contact to the metering unit steel panel via the (4) steel mounting screws used to secure the PCB mounting bracket to the panel.

IMPORTANT NOTE
There is no electrical connection from any part of the LKAT Main PCB or its optional daughter PCBs to Earth / Chassis ground or the steel PCB mounting bracket or panel. The use or non-use of the Earth Ground provision does not have any impact on the performance of the LKAT system.

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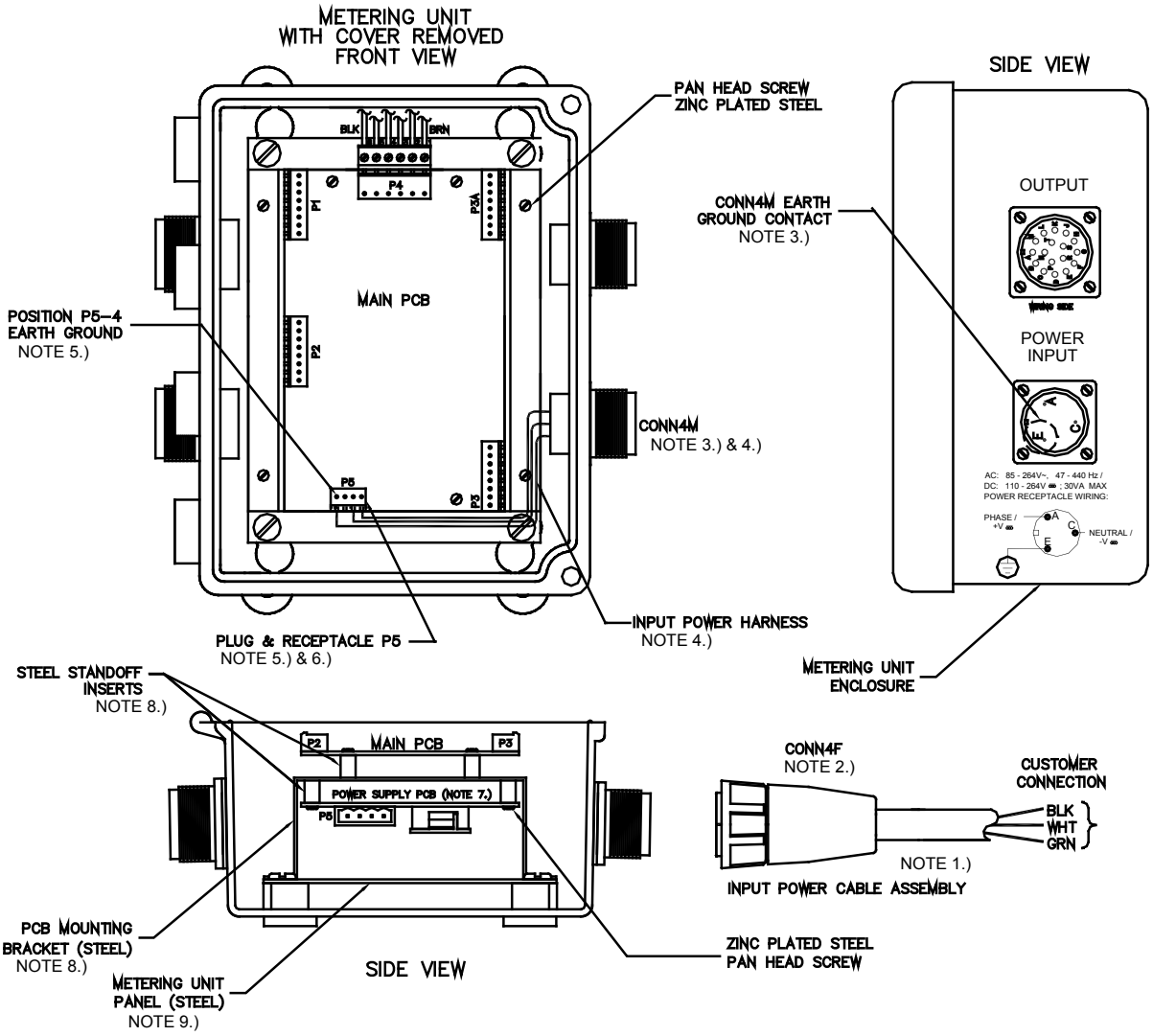

Figure 6.4
Metering Unit Earth Ground Connections

7. MAINTENANCE & SPARE PARTS

7.1 PERIODIC MAINTENANCE

As is true with any electronic system, proper maintenance will tend to prolong the service life. DynAmp, LLC recommends the following program be performed at the recommended interval to prevent or detect damage to the LKAT Plus System and to ensure reliable performance. Always use appropriate measures to correct any problems found. Following the suggested maintenance schedule may assist in early diagnosis of problem(s) to minimize repairs and down time.

IMPORTANT NOTE:
If Main pc board LED D6 (AD Status LED) is illuminated RED and / or the status relay coil de-energizes, a fault condition may exist in the LKAT Plus electronics. When this occurs, the system may require immediate attention. Refer to "Troubleshooting Fault Indication", in the "Theory of Operation" section of this manual.

7.2 ANNUAL MAINTENANCE

Refer to the "Calibration" section of this manual for calibration intervals.

If possible, perform the steps described in section titled "SYSTEM CHECKOUT DURING TEMPORARY INSTALLATION" at least once per year to verify performance of the LKAT Plus system. This may help to prevent or detect damage to the system and to ensure reliable performance. Use appropriate measures to correct any problems found. If LKAT Plus System equipment is exposed to outdoor temperatures, DynAmp, LLC recommends these steps be performed during the hottest time of the year.

In addition, the following steps should be performed once each year as part of annual maintenance:

1. Visually inspect measuring head and interconnection cable for evidence of severe overheating, cracks, separation of bonded surfaces, or excessive corrosion. Record any suspect conditions.
2. Inspect and adjust the tension of the mounting clamp plungers as needed.
3. Visually inspect metering unit and signal converter(s) for evidence of severe overheating, corrosion, or condensation. Record any suspect conditions and take appropriate action.
4. Clean as necessary; remove any oil or grease with a mild detergent. Do not use abrasives or strong chemical solvents as they may damage the cables or erase the silk-screen markings from the metering unit.
5. Disconnect power to the system before servicing or replacing fuses.

CAUTION
To avoid the risk of shock and electrocution, always disconnect all cable assemblies before performing any cleaning or service operation on the metering unit.

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7.3 RECOMMENDED SPARE PARTS

The following table lists the minimum recommended quantities for spare parts for the LKAT Plus system. As spares are used, replacements should be ordered. Since continuous operation of high-current measurement systems is often critical, stocking spare parts should be given high priority.

Some cable assemblies for the LKAT Plus System include circular connectors. Others use solder cup connectors assembled with adhesive-lined shrink tubing covering the connector shell. If connector(s) are severed from the associated cable assembly, field installable replacement connectors may be purchased. These connectors may also be installed after routing head interconnection cables in conduit. Over-molded replacement cable assemblies may be purchased for the power input and output cables. Head cable connector(s) must be replaced by field installable type(s), or with a new head. Refer to Spare Parts List Table 7.1

The LKAT Plus system measuring heads require special repair procedures and materials. However, the heads are very reliable and should require little or no repair over its service life. Please refer to the nearest authorized DynAmp , LLC service center for information on repairs.

Table 7.1
Spare Parts List

DESCRIPTION	ITEM NO.	QUAN.
Fuses, 2A 250V Slo-Blo 5mm x 20mm (5 per box)	43054	1 box
Clamp Assembly, LKAT Plus Mounting (includes 2 plungers)	43750	2
Plunger, LKAT Plus mounting 10-28 x 1” body, 1/8” hex drive	43281	2
Spare System (Head & Metering Unit calibrated as system)		1
Metering Unit	43693	
Head	*	

* Item number same as original system head

Disconnect power to the system before servicing or replacing fuses.

7.4 SERVICE ASSISTANCE

For further assistance, contact DynAmp Customer Support at:

Americas:

Telephone: +1 614.871.6900 Fax: +1 614.871.6910

8:00 AM to 5:00 PM USA Eastern Time

From first Sunday in November to second Sunday in March – 13:00 GMT to 22:00 GMT

From second Sunday in March to first Sunday in November – 12:00 GMT to 21:00 GMT

Europe:

Telephone: +41 22.706.1446 Fax: +41 22.706.1311

8:30 AM to 5:00 PM Central European Time

From last Sunday in October to last Sunday in March – 7:30 GMT to 16:00 GMT

From last Sunday in March to last Sunday in October – 6:30 GMT to 15:00 GMT

After Hours Critical Service Emergency:

Telephone: +1 614.871.6906

5:00 PM to 8:00 AM USA Eastern Time

From first Sunday in November to second Sunday in March – 22:00 GMT to 13:00 GMT

From second Sunday in March to first Sunday in November – 21:00 GMT to 12:00 GMT

Central e-mail:

help@dynamp.com

DynAmp web:

www.dynamp.com

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8. TECHNICAL BULLETINS

Table 8.1
Technical Bulletins List

NUMBER	SUBJECT	TITLE / DESCRIPTION
120131	Non-Failsafe Operation	Converting LKAT Alarm Relay Contacts to Non-Failsafe Operation

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9. DRAWINGS

Table 9.1
Drawing List

DRAWING TITLE	NUMBER
Wiring Diagram: LKAT Plus System	83A108582
Wiring Assembly: LKAT Plus Metering Unit Wiring Harnesses	83A108583
Assembly: LKAT Plus Metering Unit	84B108584
Assembly: LKAT Plus Main PCB	75A108586
Assembly: LKAT Plus Protection Extensions PCB	75A108587
Assembly: LKAT Plus RMS Display PCB	75A108588
Assembly: LKAT Power Supply PCB	26B108388
Clamp: LKAT Plus Mounting	75A045423
Outline and Mounting: LKAT Plus Sensor Head	02B108390
Outline and Mounting: LKAT Plus Metering Unit	02B108389

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